

Electronic Supplementary Information

Large Scale Production of Biomass-Derived N-Doped Porous Carbon Spheres for Oxygen Reduction and Supercapacitor

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Koutecky-Levich (K-L) plots were analyzed at a rate of 10 mV/s at RDE experiment with varying rotating speed from 400 rpm to 2025 rpm at various electrode potentials (vs. Hg/HgO). The electron transfer number (n) is calculated by the slopes of K-L plots and the Equations are as follows:

$$\frac{1}{j} = \frac{1}{j_L} + \frac{1}{j_K} = \frac{1}{B\omega^{\frac{1}{2}}} + \frac{1}{j_K} \quad (1)$$

$$B = 0.2nF(D_{O_2})^{\frac{2}{3}}\nu^{\frac{-1}{6}}C_{O_2} \quad (2)$$

where j is the experimentally measured current density, j_L is the diffusion-limiting current density, j_K is the kinetic current density, ω is the angular frequency of the rotation in terms of $\text{rad}\cdot\text{s}^{-1}$, n is the overall number of transferred electrons during O_2 reduction, F is the Faraday constant (96485 C/mol), D_{O_2} is the diffusion coefficient of O_2 in 0.1M KOH ($1.9\times 10^{-5} \text{ cm}^2/\text{s}$), ν is the kinematic viscosity ($0.01 \text{ cm}^2/\text{s}$) of the electrolyte solution, and C_{O_2} is the bulk concentration of O_2 ($1.2\times 10^{-6} \text{ mol}/\text{cm}^3$). The constant 0.2 is adopted when the rotation speed is expressed in rpm.

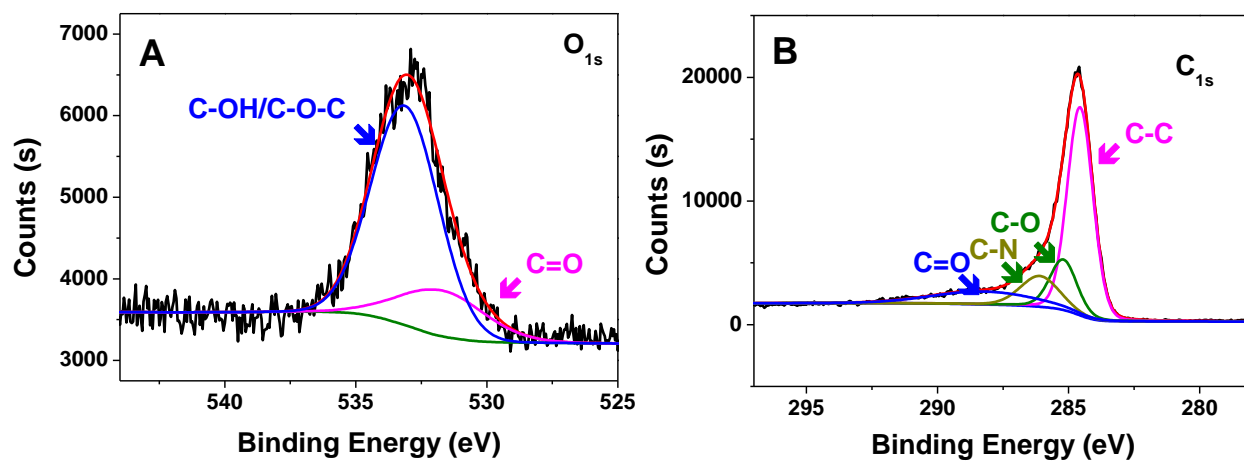


Fig. S1. High resolution O_{1s} (A) and C_{1s} (B) spectra of N-CSs.

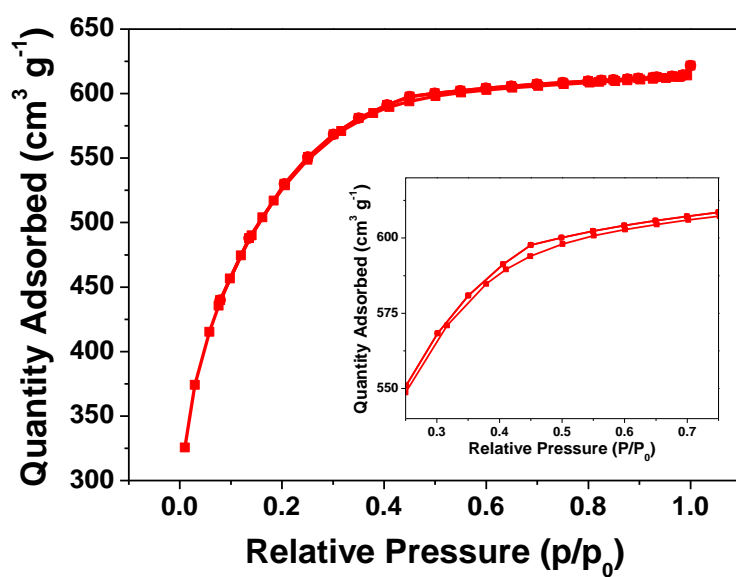


Fig. S2. N_2 sorption isotherms of samples N-CSs.

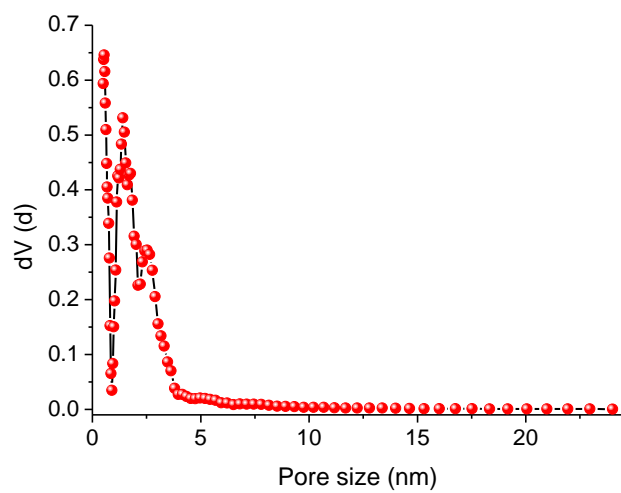


Fig. S3. Pore size distribution of N-CSs.

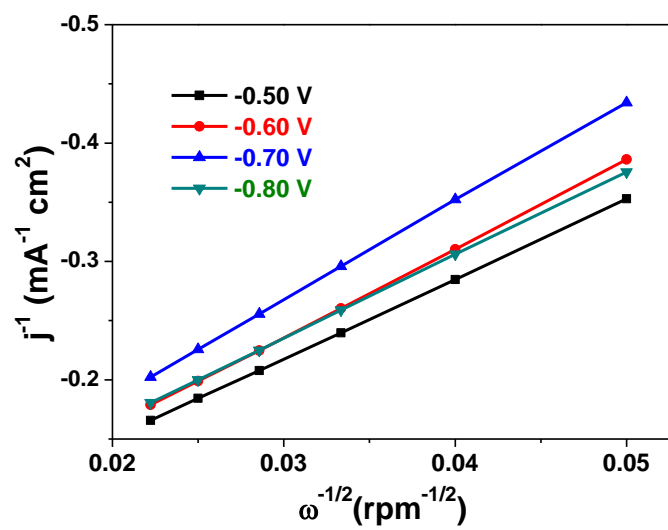


Fig. S4. The partial K–L plots derived from the RDE measurements of the commercial Pt/C.

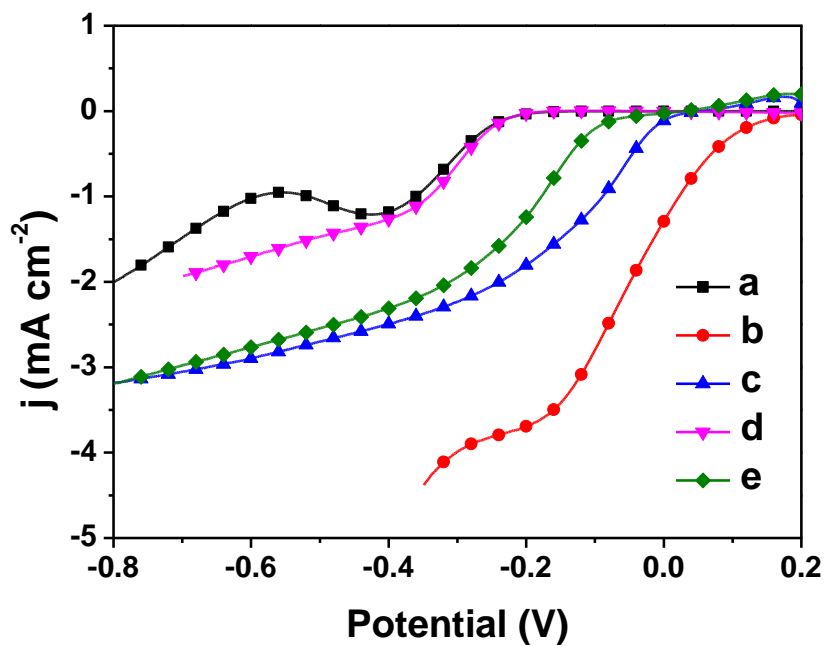


Fig. S5. RDE curves for bare-GCE (a), Pt/C (b), N-CSs (c), the directly carbonized products of fermented rice (d), and the directly carbonized products of unfermented rice (e) in O₂-saturated 0.1 M KOH with rotation speed of 1600 rpm. Scan rate: 10 mV s⁻¹.

Table S1. Structure character and elemental composition of N-CSs prepared with a pyrolysis temperature of 500 °C, 600 °C, and 800 °C, respectively.

Sample	$S_{\text{BET}}^{\text{a)}$	$S_{\text{Mic}}^{\text{b)}$	$S_{\text{Mec}}^{\text{c)}$	Pore	At.% ^{e)}		
	[m ² g ⁻¹]	[m ² g ⁻¹]	[m ² g ⁻¹]	Volumes ^{d)}	C	N	O
				[cm ³ g ⁻¹]			
S-500	3998.4	2825.8	1172.7	1.2317	78.71	10.06	11.23
S-600	2211.0	1794.28	416.6720	0.8377	82.17	8.09	9.74
S-800	1844.1	1555.98	288.1243	0.7327	87.66	5.27	7.07

a) Specific surface area from multiple BET method; b) Micropore surface area from t-plot method; c) t-method external surface area ($S_{\text{Mes}}=S_{\text{BET}} - S_{\text{Mic}}$); d) Total pore volume at $p/p_0= 0.99$; e) Atomic ratio data from XPS analyses.